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ABSTRACT

This report describes a 2-semester interdepartmental sequence which is one phase of an innovative 5-year program leading to a bachelor's degree and certification as a teacher of industrial education. During this first phase, the prospective teacher is expected to gain understandings, build attitudes, and develop special abilities needed as a teacher in a new program for industrially directed youth. The sequence consists of 4 semester hours each of general chemistry and physics as well as 6 semester hours each of mathematics, English with a major emphasis upon technical communication, and industrial education with a major emphasis upon the basic materials (woods and metals), processes, and products of modern industry. Instruction is cooperatively planned and directed by a team of four teachers, each representing a different discipline, and instructional approaches include independent study, a close association with industry, and solution of a series of correlating problems in which students solve problems requiring knowledge in two or more disciplines. Objectives and instructional outlines for 10 correlating problems are provided, and supplementary materials are appended. (SB)

THE
PARTNERSHIP
VOCATIONAL EDUCATION
PROJECT

A Two-Semester Interdepartmental Sequence

A Program of Correlated Instruction for University Freshmen

COMMUNITY COLLEGES
CMU
INDUSTRY SCHOOLS

Central Michigan University
Mount Pleasant, Michigan

ED0 47089

THE INTEGRATION OF LEARNING

through the solution of

CORRELATING PROBLEMS

one phase of a

FIVE-YEAR PROGRAM

for the preparation of

a new breed of

TEACHERS OF INDUSTRIAL EDUCATION

sponsored by

THE FORD FOUNDATION

in cooperation with

CENTRAL MICHIGAN UNIVERSITY

prepared by the staff of

THE PARTNERSHIP VOCATIONAL EDUCATION PROJECT

1967

PREFACE

At the beginning of the 1965-66 academic year, Central Michigan University, under sponsorship of The Ford Foundation, began a program of experimental education designed to produce a new breed of teachers of industrial education. Although the total program covers five years, one of its most significant and innovative phases is the interdepartmental sequence which comes during the first year. The following pages of this report attempt to explain this sequence in some detail. The report consists of three parts: Part I contains a brief statement of the purpose of the sequence and the theoretical basis upon which methods have been selected; Part II is a detailed presentation of the objectives of the sequence and the instructional outlines through which the objectives are attained; and Part III is the appendix which includes materials supplementary to the primary parts of the report.

It should be pointed out that, due to the experimental nature of this sequence, the program presented herein should not be looked upon as recommended practice. Rather it should be viewed as the rough design of a program which, through constant evaluation and revision, will become a polished product.

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PART I

PURPOSES AND PROCEDURES WITHIN THE INTERDEPARTMENTAL SEQUENCE

PURPOSE OF THE INTERDEPARTMENTAL SEQUENCE

The two-semester interdepartmental sequence is one phase of a five year program[1] leading to a bachelor's degree and certification as a teacher of industrial education. It is only one of a number of unique features built into an experimental approach to teacher education--an approach designed to produce a new breed of teacher equipped to offer industry-directed pupils a new type of education.

Two points of major significance are implied here: 1) that with few exceptions, the education available to youth who will become tomorrow's industrial-technical employees is grossly inadequate, and 2) that any move toward adequacy, particularly when that move involves new curricula and different instructional techniques, demands a new kind of teacher.

Recognizing the inadequacy of educational opportunity for the industrially directed segment of our adolescent population, certain of Michigan's secondary schools and community colleges, various Michigan industries, The Ford Foundation, and Central Michigan University have formed a "partnership" in an effort to fill this long standing void in educational offerings. Working cooperatively, these agencies have brought a totally new educational program--The Partnership Vocational Education Project--to the high schools and community colleges of Michigan.

It is recognized, however, that the success of the new program depends largely upon the degree to which its teachers accept the philosophy upon which it is based and the extent of their willingness and ability to effectively employ the unique methods required. While concentrated programs of in-service education, supported by extensive on-the-job supervision, have adequately prepared teachers in sufficient numbers to meet the immediate demands of participating schools, such measures are totally inadequate and must be replaced

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[1] For a detailed explanation of The Five Year Teacher Education Program see pages) of the Appendix.

by more effective and less expensive methods. To prepare teachers properly and to prepare them in sufficient numbers to meet anticipated needs it will be necessary to establish on-going programs within the framework of existing teacher education institutions. The Five Year Program is an attempt to do just this. On a limited basis, The Partnership Project has established an experimental program which is attempting to produce this new breed of teacher. Initially, the program is restricted to the preparation of industrial education teachers, with the thought that, if successful, it should be extended to other disciplines.

PROCEDURES WITHIN THE INTERDEPARTMENTAL SEQUENCE

Although each year of The Five Year Teacher Education Program has certain features which depart from traditional teacher preparation practices, perhaps the most unique feature of the total program is the interdepartmental sequence which comes during the first year. It is during this phase of his preparation that the prospective teacher is expected to gain the understandings, build the attitudes, and develop the special abilities that will be demanded of him when he becomes a teacher within the new program of education for industrially directed youth.

It is the theory of The Partnership Project that the attitudes and methods of teachers are largely the product of their total educational experience at the elementary, high school, and college level. Teachers think as their teachers thought, and they teach as their teachers taught. The majority of today's teachers have been exposed to years of the one-teacher, one-text, one-room method. Many of these teachers believe that learning is a process of passive absorption of fragments of isolated information and they teach accordingly. This is the method they understand, it is the method they accept, and it is the method with which they feel comfortable and secure. They have great difficulty and even some reluctance in accepting and employing methods which depart significantly from the traditional. If, however, the methods and attitudes of teachers are largely the product of the methods and attitudes of their teachers before them, it seems reasonable to conclude that they will more readily accept a new method and become proficient in its use when a significant part of their own education has been acquired through that method. Accordingly, the technique employed within the interdepartmental sequence is one of total immersion. The student is thoroughly exposed to the philosophy, objectives, and methods of the new program of education for industrially directed youth. As a student he becomes intimately involved in a program of instruction which seeks the same general objectives he will seek, covers the same general areas of subject matter he will cover, and employs the same instructional methods he will be expected to employ when he becomes a teacher at the high school or community college level.

Total Integration Gives Applicability and Adaptability

The new program of education for industrially directed youth is aimed at giving the individual a markedly increased applicability and adaptability. The rapid change and growing complexity of modern industry demands that the industrial employee of tomorrow must not only be able to apply himself with greater effectiveness to increasingly difficult tasks, but he must also be able to adapt quickly and efficiently to new materials, new processes, new products, and new responsibilities. Such abilities are not developed through the provision of an education which features the accumulation of neatly packaged fragments of knowledge and the attainment of isolated skills. Nor are they developed through an education restricted to academic accumulation without meaningful application. Rather, such abilities are developed through an education which is both sound in fundamental coverage and integrative in method. That is, it must provide for the attainment of knowledge and skills basic to industrial-technical pursuits and, at the same time, it must unify knowledge to the point that it is comprehensible, purposeful, and fully within the command of the individual. For only through purpose will the individual seek, and only through seeking will he find, and only through the finding of a comprehensible knowledge will he gain its command. To bring unity to knowledge, a number of meaningful relationships must be established: 1) knowledge must be related to knowledge, fragment by fragment, 2) appropriate knowledge must be related to specific industrial tasks similar to those the individual will be asked to perform as an employee, and 3) knowledge must be related to the individual's personal occupational goal.

Integration of Learning Through the Correlation of Instruction

The integrative process is initiated and sustained through a modified version of the correlated approach to instruction. Traditionally, the correlated approach has emphasized, and has tended to be restricted to, the establishment of mutual relationships between subject matter from two or more disciplines. As was pointed out, however, the theory of The Partnership Project suggests that comprehension, purpose, and facility are given to formal education when such is directly related to personal occupational goals and specific occupational tasks. Accordingly, correlation, as employed within The Project, implies the establishment of the full range of meaningful relationships between the individual, his formal education, and the industrial-technical world he will enter.

The Interdepartmental Sequence

Although the objectives and methods of the interdepartmental sequence are very similar to those of the new program of education for industrially directed youth, there are two significant differences. First, at the University level, higher academic attainment is expected. At both levels the program of instruction centers around a body of English, industrial education, math, and science courses which provide the knowledge and skills basic to industrial-technical pursuits. However, while the high school student is expected to acquire the basic fundamentals, the University freshman is expected to perform at a much higher level. Second, where the large majority of students at the high school and community college levels are industrially directed and are oriented to industrial-technical occupations, University students are teacher directed and are oriented to industry and industrial occupations as such.

Specifically, the interdepartmental sequence consists of the following courses in the hours indicated:

- 4 semester hours of general chemistry
- 4 semester hours of general physics
- 6 semester hours of mathematics: slide rule, college algebra, and trigonometry
- 6 semester hours of English with a major emphasis upon technical communication
- 6 semester hours of industrial education with a major emphasis upon the basic materials (woods and metals), processes, and products of modern industry.

The program of instruction is directed by a team of four teachers, each a subject matter specialist within one of the four disciplines represented. These teachers plan as a team but do not necessarily teach as a team. Although the program encourages team teaching wherever feasible, it does not demand such. Learning experiences are so designed that instructors can function within the traditional framework in which one teacher teaches one subject within a standard period. Cooperative team planning is vital, however. The degree to which meaningful relationships are established depends largely upon the ability of instructors to carry out well coordinated activities within the individual classrooms. This necessitates detailed planning and an intimate knowledge of the instructional activities of other members of the team on a day to day basis.

Within the interdepartmental sequence, the desired skills and knowledge are taught and the necessary relationships are established through the solution of a series of correlating problems. The correlating problems are directed to the student and each problem is so designed that the student must: 1) acquire knowledge and develop skills within two or more of the four disciplines, 2) mentally relate this knowledge and skill to the problem, and 3) effectively apply such to its successful solution.[1] In bringing the various fragments of knowledge together, the pupil immediately establishes certain relationships between and recognizes the mutually beneficial aspects of various disciplines; and in applying the knowledge to the solution of a meaningful industrial-technical problem, he not only establishes relationships between formal knowledge and the world of work but he sees the value and practical use of classroom experience. Additionally, in accepting the challenge of the problem and in bringing it to a successful conclusion, the student learns to accept responsibility, builds self-confidence, and gains experience in the application of knowledge and skills.

The specific objectives of the interdepartmental sequence, the correlating problems through which the objectives are obtained, and the instructional sequence for each of the problems are presented in Part II of this booklet. An examination of the instructional sequences shows that each problem has been broken down by subject and, in turn, each subject has been subdivided into three categories labeled "problem study", "related study",

[1] See pages 58-61 of the Appendix for an example of a student's written report of correlating problem.

and "other study." "Problem study" is defined as that study which is essential to the solution of a particular problem--the development of the skills, knowledge, and understandings necessary to its solution. "Related study" is defined as that study which is not essential to the solution of the problem but which is so closely related to it that student interest will carry over and relationships established within the problem can be extended to include the new material. "Other study" is defined as that study which does not relate to the problem at hand but which is necessary to the attainment of important objectives which cannot be attained through problem or problem related study. By so categorizing the study which is to be developed around each of the correlating problems, each instructor is made fully aware of the part he and his discipline must play in its solution. He is also made aware of the subject matter being covered by other members of the instructional team during a particular phase of the course. In addition, the inclusion of "related study" and "other study" provides the instructor with a valuable instructional tool as well as much needed flexibility. Experience has shown that it is extremely difficult to design a set of meaningful problems to cover all the stated objectives, and it has further shown that it is equally difficult to design problems that require approximately equal amounts of instructional time within each of the four classrooms. Consequently, when learning experiences are restricted to the activities essential to the solution of a given problem, "knowledge gaps" and "time gaps" frequently appear. However, by bringing in related and other study as time permits and as objectives demand, such gaps can be largely eliminated.

It is apparent that the instructional sequences which accompany each of the correlating problems provide only a general description of the subject matter to be covered and indicate the approximate point at which it is to be covered. The techniques to be employed, the subject matter to be covered, the resource materials to be used, and other specifics of daily or weekly instruction must be cooperatively planned by the instructional team a few days in advance of the actual presentation.[1]

The interdepartmental sequence stresses two supplemental activities which grow out of the correlating problems and further the integrative process as well as aid the development of basic skills and knowledge. One of these is <u>independent</u> <u>study</u>. To serve the varied needs, interests, and abilities of individuals and to develop ability in the identification, pursuit, and solution of significant industrial-technical problems, students are encouraged to work alone and/or in small groups in studies which grow out of assigned problem study.[2] Such studies are particularly suited to the more capable student whose ability and interest enable him to engage in meaningful learning experiences that would not otherwise be available. The second of the supplemental learning experiences is provided through the maintenance of a close association with industry. Through study trips, visitors from industry, the use of resource materials, and other means, formal classroom experience is closely related to the materials, processes, products, and trends of modern industrial technology. These activities are extremely valuable in providing the prospective teacher with a first-hand knowledge of industrial tasks and industrial occupations suitable for pupils at the high school and community college levels.

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[1] See page 57 of the Appendix for a detailed plan covering one week's work.

[2] See pages 61-65 of the Appendix for an example of a student's written report of an independent study.

PART II

OBJECTIVES AND INSTRUCTIONAL OUTLINES OF THE INTERDEPARTMENTAL SEQUENCE

OBJECTIVES OF THE INTERDEPARTMENTAL SEQUENCE

It is the purpose of the interdepartmental sequence to develop within the student:

I. The ability to identify significant industrial-technical problems and to relate and effectively apply skills, knowledge, and understandings to the solution of such.

II. The capacity to accept responsibility and to become self-directive in the meeting of responsibilities.

III. The ability to accept change and to initiate such as new methods are demanded by an increasingly complex and rapidly changing industrial-technical society.

IV. The ability to design and engage pupils in learning experiences which are articulated both vertically and horizontally.

V. An integrated body of skills, knowledge, and understandings necessary to effective functioning as a teacher of industrially directed youth. This suggests development of the following abilities within the subject areas indicated:

A. In industrial education (wood and metal technology), the ability to:

1. describe and demonstrate a degree of skill and technique in the use of common tools and machines.

2. identify and demonstrate safe practices and procedures.

3. identify and demonstrate industrial applications of power and energy in a technical society.

4. demonstrate a pride of workmanship and a sense of self-respect.

5. interpret, state, and apply sound principles of design and planning.

6. describe and demonstrate skill in product testing and quality control.

7. distinguish, describe, and demonstrate the products of American industry in terms of organization, materials, processes, and operations.

8. identify, demonstrate, and interpret the importance of materials testing--the mechanical, chemical, and physical properties of hard and soft materials.

9. identify, define, and interpret basic concepts related to industrial processes and practical application of scientific principles.

B. In science (general physics and chemistry), the ability to:

1. name and identify the classification of chemical and physical properties of substances.

2. interpret the nature of atoms in order to understand the differences in elements and the ways they react (periodic law and table).

3. interpret the important formulas of elements, those that form acids and those that form bases, so as to be able to identify the preparation and use of acids, bases, and salts.

4. name and identify the source of important metals and demonstrate their effective uses and conservation.

5. demonstrate and identify the properties of carbon to account for the great variety of its compounds, and study the production and use of these compounds for food, fuel, and industrial products.

6. interpret the relationships of matter and energy.

7. interpret the mechanics of liquids and gases in order to describe and construct various devices and machines.

8. name, identify, and demonstrate the behavior of molecules to help interpret the nature of matter.

9. interpret and demonstrate force and motion so as to relate work, power, and energy to machines.

10. identify and demonstrate the effects of heat upon matter so as to be able to explain the nature of matter and to explain how machines, through use of heat energy, can be used to accomplish work.

11. interpret the nature of sound and light and the use of each.

12. describe electricity and explain its use in chemical processes such as heating and lighting, the distribution of power, and communications.

13. interpret the field of modern physics that is concerned with electronics, radioactivity, and nuclear energy.

14. interpret and demonstrate the scientific method of problem solving.

15. identify and interpret the principles, concepts, and facts through which the student can better describe the nature of the earth, its inhabitants, and the universe.

16. describe and order effectively the natural resources of the earth as well as the products of science and technology.

17. interpret the social functions of science in relationship to the implications of science and technology in society.

18. identify and order the science concepts which will contribute positively to the student's physical and mental health and his recreational interests.

C. In mathematics, the ability to:

1. operate the slide rule efficiently in the areas where its use applies.

2. interpret the needed mathematical tables effectively and interpolate without hesitation.

3. recognize and categorize the various types of mathematical problems as they are presented in industrial education and science.

4. demonstrate basic algebraic skills accurately.

5. interpret and solve problems that demand extensive knowledge of plane, solid, and analytic geometry.

6. determine the nature of an algebraic function and represent it graphically.

7. collect data and recognize any significant characteristics of its graph.

8. recognize the relationship between constants and variables of algebraic functions and the effects of their change graphically.

9. solve problems that require the skills and knowledge of numerical trigonometry of the right triangle.

10. recognize graphs of trigonometric functions as they appear in industry, business, and science, and interpret their meanings.

11. analyze and solve problems of a trigonometric nature using vectors and topographic diagrams.

12. operate the automatic calculator.

13. apply mathematical concepts, through a problem solving approach, to the requirements of his environment.

D. In English, the ability to:

1. describe and write the four forms of discourse.

2. demonstrate research techniques.

3. distinguish among different types of technical writing materials: (a) memos, (b) letters, (c) recommendation reports, (d) informal laboratory reports, (e) proposals, and (f) formal reports.

4. distinguish among different types of literary analyses: (a) character analysis, (b) evaluation, (c) historical, (d) point of view, (e) comparison-contrast, (f) structure, (g) specific problem, (h) summary, (i) general critique, (j) close reading of passage, (k) ideas, (l) imagery, (m) tone, (n) prosodic analysis, and (o) style.

5. construct: (a) a limited subject, (b) a thesis sentence, (c) an outline for organization, (d) an introduction for a report, (e) the body of a report, (f) the conclusion of a report, (g) the bibliography for a report, and (h) an appendix for a report.

6. construct the organization for a report through a table of contents and sectional headings.

7. construct an annotated bibliography.

8. interpret scientific, mathematical, and technical information for: (a) facts, (b) ideas, (c) organization, (d) principles, (e) directions, (f) problem solving, (g) definitions, and (h) understanding and interpreting graphic materials.

9. interpret literary material for historic, economic, sociological, and political implications.

10. demonstrate an understanding of oral communication.

CORRELATING PROBLEMS

The daily learning experiences for students within the Interdepartmental Sequence center around the series of Correlating Problems which follow. The problems should be presented to the students who will accept individual responsibility for solving the problem and reporting the results as specified. Instructors may find it necessary to modify problems according to individual needs and interests, easing requirements for the less able student and encouraging the more capable individual to explore in greater depth. It might appear advisable at times to permit individuals or small groups to discard the stated problem in favor of particular aspects which they find more exciting and more challenging.

Instructors should meet periodically to determine when the upcoming problem is to be introduced, which instructor is to introduce it, just how it is to be introduced, and the specific facets of the problem to be dealt with in each of the four classrooms on a day to day basis.

PROBLEM # 1

The Problem

Design and fabricate a template and gage according to the following specifications:

1. The template must have three openings, one of the openings must be circular with a diameter of two inches, the two remaining openings may be any shape or size so long as they fit the demands of the problem.

2. The gage must pass through all three of the openings, completely filling each opening with a tolerance of no more than 1/32".

3. All surfaces must be sanded and waxed.

Suggested Procedure

1. Prepare a full scale pictorial sketch of the template.

2. Prepare a full scale orthographic drawing of the gage.

3. Select materials and fabricate the template and gage according to the drawings.

4. Sand and wax all surfaces.

Evaluation

Evaluation will be based upon the quality of the drawings, the precision of the template and gage, and the quality of the finish.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Drawing 2. Wood selection. 3. Fabrication of template and gage 4. Finishes for template and gage 5. Tests for measurements	1. Wood identification: a. types b. kinds c. uses d. grades 2. Common finishes 3. Cost of materials	1. Safety practices and procedures 2. Lumber harvesting and lumber products 3. Lumber purchasing and grading 4. Industrial uses of wood and wood products	1. Scientific measurements 2. Wood identification: a. types b. kinds c. uses d. grades 3. Finishes and preservatives	1. Life processes of trees 2. Tree identification 3. Physical and chemical properties of woods 4. Forest products and industrial materials: a. paper b. tar c. gas d. etc.	1. Safety practices and procedures 2. Laboratory procedures 3. Archimede's principle and experiment 4. Hooke's law and experiment 5. Periodic law and its functions 6. Physical and chemical changes

Problem # 1

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Mathematical calculations of geometric figures 2. Tests of measurements	1. Board foot rule and computations 2. Cost of materials	1. Slide Rule techniques 2. Use of trigonometric functions in industrial applications (e.g., vectorial forces)			1. Four forms of discourse: a. expositive b. descriptive c. argumentative d. narrative 2. Technical writing process: from problem to answer to explanation 3. Informal reports: a. laboratory b. progress c. recommendation d. proposal 4. Letters of introduction

Examples of successful correlation: Problem # 1

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 2

The Problem

Determine the methods, advantages, and disadvantages of laminating woods.

Suggested Procedure

1. Prepare a number of laminated specimens using a variety of common woods and adhesives.
2. Compare laminated specimens with solid specimens of equal dimensions by testing for compression and tension.
3. Collect data.
4. Draw conclusions.
5. Prepare a recommendation report.

Evaluation

1. Skill in preparation of laminated specimens.
2. Preparation of recommendation report.
3. Knowledge of methods of laminating.
4. Knowledge of advantages and disadvantages of laminating.
5. Knowledge of testing.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Principles of design 2. Identification of woods 3. Physical properties of woods: a. durability b. workability c. weight 4. Types of adhesives 5. Testing of specimens.	1. Characteristics of wood: a. hardwoods b. softwoods 2. Strength of glued structures 3. Preparation of wood.	1. Products of plywood and veneer mills 2. Veneer and plywood manufacture 3. Wood by-products: a. hardboard b. particle board 4. Paper industry.	1. Adhesion 2. Cohesion 3. Chemical and mechanical properties of adhesives.	1. Forest products and industrial materials[1] a. paper b. tar c. gas d. etc.	1. Atoms, ions, and subatomic particles 2. Motion and complex motion: a. projectiles b. falling bodies

[1] Chris H. Groneman and Everett R. Glazener, *Technical Woodworking*, St. Louis: Webster Division, McGraw-Hill Book Company, 1966, pp. 72-75.

Problem # 2

Mathematics			English		
Problem Study	**Related Study**	**Other Study**	**Problem Study**	**Related Study**	**Other Study**
1. Testing of joints: a. graphs b. ratio and proportion		1. Basic trigonometry: a. natural functions b. solving triangles	1. Recommendation report: a. interpretative b. persuasive	1. Writing process: a. preparing b. assembling materials c. sorting materials d. planning e. organizing f. classifying g. arranging h. ordering i. writing j. criticizing and revising.	1. Subject for formal report 2. Format for formal report: a. letter of transmittal b. title display c. synopsis d. table of contents e. introduction f. body g. terminal section h. bibliography i. appendix 3. Thesis sentence 4. Outline: a. introduction b. body c. conclusion 5. Sources of information

Examples of successful correlation: Problem # 2

Evaluation of problem:

Suggestions for independent study:

The Problem

Through experimentation with basic types of joints:

A. determine:

1. the types of metal fasteners that give the greatest strength (tensil and compression).

2. the types of adhesives[1] that give the greatest strength.

3. the combinations of fasteners and adhesives that give the the greatest strength.

B. prepare a written report which shows the data collected and findings of the tests. Test data should be shown graphically.

Suggested Procedure

1. Through study, determine the various types of joints, the metal fasteners and adhesives employed in making joints, and the theoretical advantages and disadvantages of each.

2. Select certain basic types of joints, fabricate specimens with the various fasteners and adhesives, test specimens, and collect data.

3. Prepare a written report of the findings (include recommendations).

Note: joint specimens should be made of white pine and should be 3/4" x 1" x 10" when finished.

Evaluation

Evaluation will be based upon the report and the validity of the data upon which the report is based.

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[1] The Forest Products Laboratory, Wood Handbook No. 72, Washington 25, D. C.: U. S. Department of Agriculture, 1955, pp. 236-237; Chris H. Groneman and Everett R. Glazener, Technical Woodworking, St. Louis: McGraw-Hill Book Company, 1966, pp. 297-298.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Joinery 2. Selection of: a. woods b. joints c. adhesives 3. Preparation of joints 4. Application of adhesives 5. Assembly of joints 6. Testing of joints	1. Industrial uses of adhesives 2. Adhesives: a. thermoplastic b. thermosetting 3. Fasteners and reinforcements: a. splines b. corner c. plates 4. Mechanical advantage: a. driving tools b. withdrawing tools	1. Strength of rigid structures: a. stresses and strains b. shears c. bending moments 2. Building codes	1. Mechanical properties of adhesives 2. Forces in equilibrium 3. Dynamics 4. Machines: a. operation b. efficiency c. mechanical advantage	1. Force vectors	1. Studies of motion

Problem # 3

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Graphs	1. Graphs of trigonometric functions	1. Basic algebra	1. Proposal: a. offer b. plan c. costs		1. Outline
2. Ratio and proportion: a. efficiency b. mechanical advantage	2. Arithmetical and geometrical progressions				2. Sectional headings 3. Planning introduction 4. Writing introduction
	3. Vectors				5. Introduction: a. precise subject b. writer's attitude c. plan
					6. Topic sentence development
					7. Paragraphs: a. development b. relation c. coherence
					8. Sectional headings: a. main headings b. second-order headings c. third-order headings d. agreement of headings, outline, and table of contents

Examples of successful correlation: Problem # 3

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 4

The Problem

Through experimentation and testing, derive a rule, chart, formula, or other device for calculating a truss design which gives the maximum ratio of supportive strength to weight of the truss.

Suggested Procedure

1. Determine mathematically the design of a type of rigid structure (a pitched roof[1]).

2. Prepare a full scale working drawing of the design.

3. From this drawing fabricate three trusses according to the following specifications:

   a. scale: 1" = 1'
   b. span: 24'
   c. rise: 8'
   d. rafters: 2" x 6" on 16" centers
   e. maximum length of stock: 75" per truss
   f. kind of wood: optional
   g. decking: 1/8" plywood.

4. Apply decking to the trusses.

5. Construct a testing device which will measure the breaking point of the structure and test to determine the ratio of supportive strength to weight.

6. Record findings and prepare a formal report which includes the rule, chart, formula, or other device for finding a given truss design which gives the maximum ratio of supportive strength to weight of truss.

Evaluation

Evaluation will be based upon the mathematical design, the working drawing, the derived formula or other device for calculating truss design, and the formal report.

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[1] W. Fleming Scofield and W. H. O'Brien, William A. Oliver (rev.), Modern Timber Engineering, New Orleans: Southern Pine Association, Chapters IV and VI; Groneman, Technical Woodworking, Section 24.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	**Related Study**	**Other Study**	**Problem Study**	**Related Study**	**Other Study**
1. Wood selection	1. Components of roof frame: a. span b. run c. rise d. pitch	1. Prefabricated housing	1. Forces in equilibrium	1. Mechanics: a. work b. power c. energy	1. Frames of reference: a. relative motion b. accelerated motion c. equivalence d. etc.
2. Calculations	2. Types of trusses and their uses: a. king b. queen	2. Mobile homes	2. Dynamics	2. Forces: a. motion b. centripetal c. centrifugal d. moments e. etc.	
3. Graphic illustrations of trusses (sketches)	3. Methods of assembly: a. gussets b. rings	3. Building construction industry	3. Mechanics: a. mechanical advantage b. test apparatus construction		
4. Working drawings	4. Rafter layout	4. Thermal characteristics of wood			
5. Layout	5. Building codes				
6. Rigid structure fabrication					
7. Test apparatus construction					
8. Testing of rigid structures					

Problem # 4

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Calculations 2. Design: a. vectors b. Pythagorean theorem 3. Ratio and prcportion 4. Rule, chart, or formula	1. Vectors	1. Basic algebra	1. Formal report		1. Terminal section: a. factual b. critical c. advisory d. combination

Examples of successful correlation: Problem # 4

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 5

The Problem

Involving the basic concepts previously studied, fabricate a marketable product through mass production.

Suggested Procedures:

1. **Design and prepare a working drawing.**
2. **Select materials and determine processes.**
3. **Prepare a prototype.**
4. **Prepare a progress report.**
5. **Lay out production and flow charts.**
6. **Fabricate product.**

Evaluation

Evaluation will be based upon the quality of the design, the progress report, and the mass production process (efficiency and use of time and materials).

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Custom and mass production principles 2. Product design 3. Selection: a. woods b. joints c. fasteners d. finishes 4. Working drawings 5. Prototype 6. Production chart 7. Flow chart 8. Fabrication of product.	1. Summarization of concepts 2. Organizational structure of an industry.	1. Pattern making 2. Numerical and tape control	1. Summarization of concepts.		1. Temperature and heat: a. measurement b. temperature c. change by energy transformation c. heat exchange d. heat transfer without temperature change e. thermal behavior of various materials 2. Heat and microstructures: a. kinetic b. specific heat c. nature of heat d. heat engine e. principles of thermodynamics.

Problem # 5

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Summarization of concepts 2. Cost analysis: a. time b. materials	1. Basic calculus in industrial usage	1. Basic algebra	1. Progress report		1. Formal report

Examples of successful correlation: Problem # 5

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 6

The Problem

Using patterns previously fabricated, sand cast five geometric solids (sphere, cone, cylinder, cube, and regular tetrahedron) according to the specifications given below:

1. Solids must be cast of metals having the following properties:

   a. The melting point must be between 300 and 1600 degrees F.
   b. Metals must be noncombustible at 1200 degrees F. (approx.)
   c. Must be noncorrosive.
   d. Must be easily available at reasonable cost.

2. All castings must be of equal volume.

3. The sphere (to be provided) must have a diameter of 2".

4. The castings must be given a desirable finish.

5. Prepare a proposal on casting.

Suggested Procedure

(To be determined)

Evaluation

Evaluation will be based upon the precision of the volumetric measurement, the quality of the castings, and the quality of the proposal.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Safety practices and procedures	1. Types of patterns	1. Sand conditioning and control	1. Metallurgy of the elements used in the problem	1. Physical and chemical properties of non-metals	1. Qualitative analysis experiments
2. Applying shrink rule	2. Types of sands	2. Heat treating processes	2. Heat processes: a. specific heat b. coefficient of expansion c. shrink rule	2. Periodic law and functions	2. Electrical studies: a. electrostatics b. charge on electron
3. Developing patterns	3. Color codes	3. Casting specimens for Problem IV	3. Electrical processes: a. thermocouple b. electric furnace	3. Elements and compounds	
4. Gating and risering	4. Other casting processes: a. die casting b. instrument casting c. shell molding d. plaster mold casting		4. Qualitative analysis: a. group analysis b. semi-micro analysis		

Problem # 6

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Volumetric computations 2. Shrink rule development	1. Volumetric formulas: a. implementation b. derivation	1. Descriptive geometry	1. A proposal of casting procedures indicating the most desirable process under certain specifications		1. Summar theme on essay

Examples of successful correlation: Problem # 6

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 7

<u>The Problem</u>

Determine the processes through which selected metals can be forged, heat treated and finished for specific uses in industry.

<u>Suggested Procedures:</u>

1. Identify industrial uses of forged, heat treated, and finished metals.

2. Identify metals.

3. Experiment to determine heat treating processes appropriate for the metal and the industrial use of such by preparing specimens for testing and evaluation.

4. Write progress reports during experimentation.

<u>Evaluation</u>

1. Degree of skill in heat treating specimens.

2. Ability to identify quality of metal by color.

3. Progress reports.

4. Knowledge of forging, heat treating, and finishing processes.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Principles of design. 2. Forging 3. Hardening and tempering 4. Surface treating.	1. Upset forging 2. Drop forging 3. Swedging	1. Extrusion 2. Hot drawing 3. Piercing 4. Pipe welding	1. Physical and chemical properties of ferrous metals 2. Carbon-steel alloy	1. Alloys a. ferrous b. solid state c. uses	1. Experiments with qualitative analysis 2. Electrical studies: a. circuits b. energy c. power 3. Mole concept and stoichiometry

Problem # 7

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Arithmetical computations: a. percentage composition b. ratio and proportion	1. Chemical formula development: a. empirical b. molecular	1. Basic trigonometry	1. Progress reports		1. Theme on ideas on a essay 2. Theme on imagery in poetry

Examples of successful correlation: Problem # 7

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 8

The Problem

A. Fuse by cohesion a parallelepiped using the oxyacetylene welding process according to the following specifications:

1. Stock must be 1/8" mild steel.

2. The completed figure must measure 3/4" x 3/4" x 4".

B. Arc weld by adhesion several stringer beads on a specimen using the shielded metal arc welding process according to the specifications given below:

1. Stock must be 3/16" mild steel.

2. Specimen must be 1 1/2" x 4".

C. Write a recommendation report on the most suitable welding method for a given application.

Suggested Procedure

(To be determined)

Evaluation

A. The parallelepiped must be fastened with "edge joints" and these must show full penetration; it must have true edges, and upon destruction the metal around the joint edge must show a sugar-like grain structure.

B. The stringer beads must be uniform in height, approximately one-half the diameter of the electrode, and approximately 3/4" in length.

C. The quality of the recommendation report will also be evaluated.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Safety practices and procedures	1. Welding processes: a. forge b. gas c. arc d. submerged arc e. brazing	1. Thermit welding: a. electro-slag b. electronic beam c. electro-sonic d. friction	1. Chemistry and physics of oxyacetylene welding	1. Preparation of acetylene	1. Experiments with qualitative analysis
2. Steel selection	2. Soldering	2. Surfacing	2. Cohesion	2. Chemical equations: a. oxidation b. reduction	2. Electrical studies: a. circuit construction b. electric motor
3. Oxyacetylene cutting	3. Fusing weld types and joints	3. Metal-lizing	3. Fusion	3. Electrical principles of arc welding	
4. Edge welds		4. Flame straightening	4. Chemistry and physics of arc welding	4. Principles of thermodynamics: a. welding b. temperature and thermometers c. coefficient of expansion and contraction d. melting e. freezing	

Problem # 8

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Geometry of the parallele-piped	1. Percentage of various gases in welding mixtures 2. Laws of gases 3. Temperature formulas: a. centigrade (Celsius) b. Fahrenheit c. Kelvin 4. Heat units: a. calories b. thermal units	1. Basic trigonom-etry	1. Recom-mendation reports		1. Compariso[n] contrast theme in poetry 2. Theme on close readi[ng] of a passag[e] from a sho[rt] story

Examples of successful correlation: Problem # 8

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 9

The Problem

Using an aluminum or steel rod, straight and taper turn one specimen on a metal lathe according to the specifications which follow:

1. Material:
   a. If aluminum, use one of the casting specimens from Problem # 6.
   b. If steel, use mild or carbon.

2. The diameter must be: minor--.500"
   major--.750".

3. The length of the neck must be 3.250".

4. The overall length must be 8.000".

Also, test the specimen for elongation and tensile strength and plot the results on a graph. Submit the results in an informal laboratory report.

Suggested Procedure

(To be determined)

Evaluation

Evaluation will be based upon measurements of the diameter and length of the neck of the specimen, the accuracy of the tests of elongation and tensile strength, and the quality of the informal laboratory report.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	**Related Study**	**Other Study**	**Problem Study**	**Related Study**	**Other Study**
1. Safety practices and procedures 2. Measuring instruments 3. Metal cutting: a. tool speed cutter b. high speed cutter 4. Basic components of lathe 5. Cylindrical and taper turning 6. Testing	1. Shapes and uses of cutters 2. Lathe accessories: a. centers b. chucks c. collets 3. Lathe operations: a. facing b. boring c. reaming d. knurling 4. Speeds and feeds 5. Coolants	1. Industrial uses of turning machines	1. Physical and chemical properties of aluminum, iron, and ferrous alloys 2. Hooke's Law 3. Mechanical testing	1. Construction of a testing device	1. Experiments with qualitative analysis 2. Electrical studies: a. direct current b. alternating current 3. Wave motions: a. electro-magnetic b. sound c. light d. sonar e. radar

Problem # 9

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Theory of taper turning: a. taper attachment b. tailstock offset c. compound rest 2. Evaluation of specimens for accuracy 3. Graphs of test results	1. Mechanical advantage 2. Theory of angular and linear velocities: a. speeds of lathe b. feeds of lathe	1. Basic trigonometry			1. Independent study 2. Character analysis from a drama 3. Prosodic analysis of a poem

Examples of successful correlation: Problem # 9

Evaluation of problem:

Suggestions for independent study:

PROBLEM # 10

The Problem

Form by pressing and heating (sintering) two needle-like structures from two different alloyed powdered metals; magnetize these needles permanently; use one of them in the fabrication of a simple compass; test the other for density, volume, compression, cross sectional area, and tensile strength; and graph and report the results. Do this according to the specifications and procedure given below:

1. Alloy: determine
2. Diameter: 1/16"
3. Length: 1".

Suggested Procedure

1. Produce two fine metallic powders.
2. Mix and prepare the powders.
3. Press the powders into the needle-like shapes.
4. Heat (sinter) the needle-like shapes to the required temperatures.
5. Magnetize the needles.
6. Fabricate a simple compass with one of the needles.
7. Test the specified properties of the other needle.
8. Graph and report the results.

Evaluation

Evaluation will be based upon tests of the properties of the needles and the quality of the graph and report.

Interdepartmental Instructional Sequence

Industrial Education			Science		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Selection of powdered metals 2. Mixing and blending of metals 3. Pressing 4. Sintering 5. Testing	1. Industrial applications of powdered metallurgy	1. Theoretical basis for metal forming	1. Physical properties of metals 2. Alloying process: a. heat b. pressure 3. Magnetism: a. force b. field c. ferro-magnetism d. permanent magnets e. magnetism of the earth 4. Testing	1. Magnetism: a. electro-magnetic induction b. solenoid c. induced current 2. Electro-statics 3. Electric motor	1. Experiments with qualitative analysis 2. Review: a. ions and ionization b. solubility c. chemical equilibrium d. hydrolysis e. complexions

Problem # 10

Mathematics			English		
Problem Study	Related Study	Other Study	Problem Study	Related Study	Other Study
1. Law of magnetism 2. Testing computations	1. Electro-statics: a. Coulomb's Law b. charge on electron	1. Basic trigonometry 2. Industrial calculus			1. Independent study 2. Evaluation of a novel

Examples of successful correlation: Problem # 10

Evaluation of problem:

Suggestions for independent study:

PART III

APPENDIX

CURRICULUM FOR INDUSTRIAL-TECHNICAL EDUCATION PROJECT
5 YEAR PLAN FOR TEACHERS OF INDUSTRIAL-TECHNICAL EDUCATION

First Year

Cooperatively taught by a four man team employing the CORRELATED APPROACH to instruction

4 semester hours of general chemistry
4 semester hours of general physics
6 semester hours of mathematics
6 semester hours of industrial education
6 semester hours of English

6 - 8 additional hours in required courses.

Second Year

30 - 34 semester hours in general and industrial education.

Third Year

One semester off campus internship as a "teacher assistant" in a Partnership School employing the correlated approach to instruction.

One semester on campus carrying 15 - 17 semester hours of general and special education courses.

Fourth Year

One semester off campus as a full time on-the-job learner and employee in a Partnership industry.

One semester on campus carrying 15 - 17 semester hours of general and special education courses.

Ten weeks off campus as a full time on-the-job learner and employee in a Partnership industry.

Fifth Year

One semester off campus internship as a "teacher associate" in a Partnership School employing the correlated approach to instruction.

One semestor on campus carrying 15 - 17 semester hours of general and special education courses. This includes a two semester hour course in independent study.

CURRICULUM FOR INDUSTRIAL-TECHNICAL EDUCATION PROJECT
5 Year Degree Program for Teachers of Industrial-Technical Education

			Sem. Hrs.	Totals
Group I LANGUAGE, LITERATURE, AND SPEECH				12
English	101	Freshman Composition	3	
	102	Freshman Composition	3	
Speech	101	Fundamentals of Speech	3	
Electives			3	
Group II SCIENCE				20
Mathematics	119A	Algebra & Trigonometry	2	
	119B	Algebra & Trigonometry	3	
	131	Slide Rule Calculations	1	
Physics	120	Physics for Technology	4	
Chemistry	120	Introductory Chemistry of Materials	4	
Health Education	106	Personal Health or equivalent	3	
Psychology	201	Introductory Psychology	3	
Group III SOCIAL SCIENCE				18
Economics	201	Principles	3	
	202	Problems	3	
Sociology	151	Introductory Sociology	3	
	152	Social Problems	3	
Political Science	201	Introduction to American Govt.	3	
Electives in Economics or Sociology			3	
Group IV EDUCATION				26
Education	335	Teaching in Secondary Schools	3	
	336	Directed Observation	2	
	337	Adolescence	3	
	338	Affiliation	2	
	363	Foundations of American Education	3	
*	364	Directed Teaching	5	
	370	Educational Psychology	3	
	371	Mental Hygiene	2	
*	374	Directed Teaching	3	

* The student must spend two semesters of internships in a Partnership School.

			Sem. Hrs.	Totals
Group VI APPLIED ARTS				50
Commerce	260	Principles of Management	3	
	320	Personnel Management	3	
Industrial Education	101	Engineering Drawing	3	
	102	Wood Technology	3	
	111	Arts and Crafts	2	
	118	Planning and Design	2	
	119	Technical Sketching	1	
	120	Graphic Arts	2	
	122	Metal Technology	3	
	128	Introduction to Power	3	
	208	Introduction to Industrial Education	1	
	251	Electricity	2	
	324	Prob. and Meth. of Teaching I. A.	2	
	331	Electronics	3	
	351	General Shop Organization	2	
**	339	Industrial Internship	6	
	391	Independent Study	2	
Electives to establish a sequence of ten or more hours in one area of Industrial Arts ***			7	
Group VII HEALTH, PHYSICAL EDUCATION AND RECREATION				
Physical Education Activity				4
Free Electives				6
		TOTAL		136

** The student must complete one semester of industrial internship (4 semester hours credit) plus one ten week summer (2 semester hours credit).

*** The student must complete sufficient hours to have at least ten hours in one of the following areas: Drafting and Design, Graphic Arts, Wood, Metal, or Energy and Power.

WEEKLY CORRELATION

	Industrial Education	Mathematics	Science	English
MONDAY	1. Test specimens. 2. Continue fabricating drawing board. 3. Continue plans for educational tours.	1. Study sine law. 2. Continue study of linear equations and graphing. 3. 15 minute review of trig. functions.	1. Review and complete study of forces in equilibrium. a. measurements b. types c. friction d. hydrostatics e. vectors f. torque g. rotational h. center of gravity	1. Review annotated bibliography for formal reports. 2. Begin writing recommendation reports on basis of testing in industrial education.
WEDNESDAY	1. Study board feet. 2. Compute cost of materials. 3. Educational tour Morbark Debarking.	1. Board feet study in OB's room from 8-9. 2. Winn trip.	Wood Technology (Winn Trip) Dynamics: a. thermal velocity b. Newton's 2nd and 3rd Laws c. Circular Motion.	1. Write thesis sentences for formal reports. 2. Write memo on trip to Winn. 3. Continue writing recommendation reports.
FRIDAY	1. Study relative humidity of wood. 2. Continue fabricating drawing boards. 3. Introduce Problem III Joinery.	1. Finish study of linear functions and equations. 2. Graphing of tests (wood) and kiln specimens.	Experiments: 1. Boom experiment - tension 2. Center of gravity.	

Following week:

1. Collect Recommendation Reports.
2. Introduce Problem # 3.

Technical Report

of

Correlating Problem Number Six: Shaping by Casting

by

Don Berg

Problem:

If a sphere has a diameter of two inches, cast five geometric solids (cone, cylinder, cube, and tetrahedron), all of which have a volume equal to that of the sphere.

Given: a) sphere = 2" in diameter
b) cone = 2" across base
c) cylinder = .75" in diameter

1 Volume of sphere = (r^3) $(\frac{4\pi}{3})$
V = 4.1866 in.

2 Volume of cone = (1/3) $(\pi r^2 h)$
Height of cone = 4"

3 Volume of cylinder = (πr^2) (h)
Height of cylinder = 9.481"

4 Volume of tetrahedron = (1/3 A of B) (h)
Side of tetrahedron = 3.544"

5 Volume of cube = L x W x H
Sides of cube = 1.61"

Aluminum was the metal chosen for the casting of the solids because it has a low melting point, is fairly inexpensive, and is safer to cast than most metals.

In the casting of the five geometric solids, .25" was added to the base, height, diameter, length, and width to allow for machining the metal and shrinkage.

A temperature of 1550° F was found to produce the best castings. By coating the full-mold styrofoam pattern with wax a smoother casting surface was produced. Before casting the sand was tempered enough so it could be rolled into a ball, be sheared in half, and hold its own shape. Small holes produced by pushing a wire into the drag sand enabled the gas to escape when the metal was poured. Ten minutes was allowed for the metal to solidify after it was poured.

Safety precautions such as the wearing of gloves, leggings, welding helmet, and the treating of all metals as if they were hot were observed.

CONE

The height of a cone whose base is two inches and its volume 4.1866"^{3}, was found to be four inches. This height was calculated by the use of the formula: $h = \frac{V}{1/3 \text{ A of B}}$

After casting the cone to a + .25 inches in radius, the angle on the taper was calculated: ten 1/2 A = $\frac{D-d}{2L}$. The angle was found to be 28°.

There are three ways to cut a taper:

a) use of a taper attachment.
b) by offsetting the tailstock.
c) use of the compound rest.

The use of the taper attachment could have been used but the time involved in attaching it to the lathe would have been too great. The tailstock offset is used where a long but small taper is to be cut. The compound rest method was used for the turning of the cone taper.

The angle of the taper was 28° (sine $\frac{2}{4.25}$) so, (1/2) (28°) was subtracted from 90° and the proper setting for the compound rest was found. The compound rest was swiveled clockwise to 76° from normal position.

Care was taken to make sure the cutter bit was centered properly (in exact center). If the cutter bit is off center a true taper can't be turned.

Other factors involved was the sharpening of the cutter bit and the speed to turn aluminum. A smoother finish can be obtained with the proper cutting edge and by turning the metal as fast as possible.

If the aluminum becomes too hard while machining it, it can be annealed. This process involves heating the metal until it is cherry red and allowing it to cool very slowly.

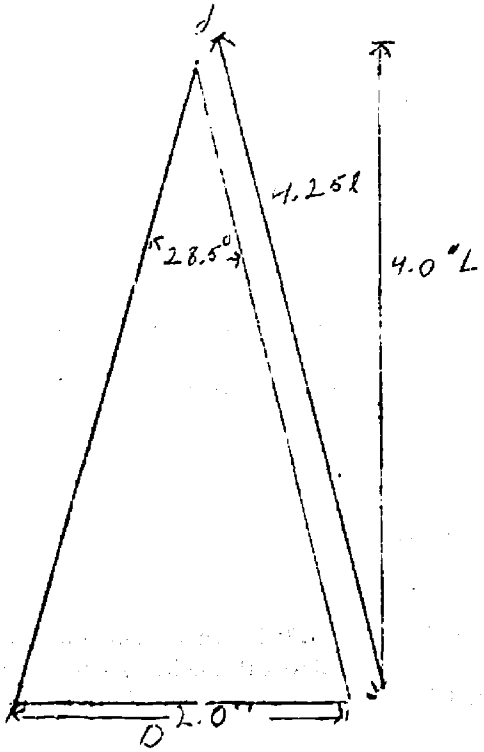
No polishing or filing was done in the operation because they would produce an untrue finish.

CUBE

The cube was cast with a 1.86" width, height, and length.

There are many ways in which to machine a flat surface. Two were used in the machining of the cube:

a) use of milling machine.
b) use of the shaper.



TPI = Taper Per Inch
TPF = Taper Per Ft.
D = Diameter of Base
d = Diameter of small end
l = Length of Taper
L = Total length of piece

$$\text{Offset} = \frac{L \times (D-d)}{2\ l}$$

Offset = .9411"

TPI = .25"
TPF = 3.0"
D = 2.0"
d = 0"
l = 4.25"
L = 4.0"

The compound rest should be swiveled clockwise 75° 45'.

The use of the two inch micrometer helped to determine the final cut for machining the cube.

Formula used to compute the dimensions of the cube: $x = \sqrt[3]{4.1866}$ $\quad x = 1.61''$

CYLINDER

The cylinder was cast with a diameter of 1.25" and a length of 10". A 10" length was cast to allow for machining of the metal between centers and shrinkage of the aluminum after pouring.

The metal lathe was used to machine the cylinder to 3/4". Several tools had to be selected in the procedure. Three cutter bits were used. The first was sharpened so it would take a rough but sizeable cut. The second was sharpened so it would produce a smooth finish. The third tool used was the cut-off tool. It was centered in the tool holder tree by running it up to the tailstock center and then centering it vertically by running it to the chuck when the lathe was not in operation.

The formula used to calculate the dimensions of the cylinder: h = height; $h = \frac{V}{\pi r^2}$
L = 9.481".

SPHERE

The sphere was cast with a diameter of 2.25". Several ways of machining a sphere include:

a) by hand filing it.
b) use of a tumbler.
c) use of a metal lathe.

The metal lathe was used to produce a sphere with a 2" diameter.

The formula used to compute the volume of the sphere: $V = (r^3)(\frac{4\pi}{3})$
$V = 4.1366''$

TETRAHEDRON

The tetrahedron was cast so its sides were 3.794" long. Machining of the tetrahedron proves difficult due to its irregular shape. Several machines can be used though. The shaper, milling machine, and a hand file were used to produce the finished dimensions for the tetrahedron.

The formula used to calculate the tetrahedron's dimensions: x = (1/3) (A of B) (h) x = 3.544".

CENTRAL MICHIGAN UNIVERSITY
Mount Pleasant, Michigan

Partnership Vocational
Education Project

INDEPENDENT STUDY

The purpose of the independent study is to provide the student with the opportunity to do individual research and experimentation. The American society has been built by individual creative ingenuity. The men who have made contributions in the development of America's highly technical society learned through actual experience the value of research and experimentation. It is our goal to have the student learn the basic concepts of the various disciplines by experimenting with materials and products.

The following are the objectives for the student who undertakes independent study under this program:

1. The student should exhibit the ability to work by himself and/or in small groups.
2. The student should show the ability to manage time effectively.
3. The student should acquire the ability to isolate a problem.
4. The student should demonstrate the ability to solve a problem.
5. The student should develop the ability to find and use reference material.
6. The student should exhibit the ability to apply various concepts and skills he has acquired in his studies of science, mathematics, English (particularly communications), and industrial technology.
7. The student should show the ability to communicate his findings.

The research and experimentation approach to teaching in the industrial education and science laboratories opens new avenues of learning. The student and instructor undertake the solving of a problem. Together, the problem is defined, the solving procedure structured, the experiment conducted, and findings recorded and reported.

Technical Report

of

An Independent Study

Harmonic Frequency and Resonance Controlled
in a closed Brass Tube by the Size and Shape
of the Opening

by

Earl Gass

May 19, 1967

SYNOPSIS

This report gives the results of experiments dealing with the size and shape of sounding boxes for a door chime. These tubes were constructed having closed ends and an opening along the length over which a tuning fork was rung. The constant arrived at through these experiments was that a tube having a 9" length and an opening 13/32" wide would amplify a tone having 3.7637 more vibrations per second every time the opening length was increased by 1.32".

CLOSED TUBE DOOR CHIME

This study involved experimentation with the size, shape, and materials of a sounding box for a door chime which would amplify the volume of a tone produced by a given sounding bar.

These tubes or sounding boxes were to be closed at both ends and have an opening at some point along the length. Since formulas could be found only to determine the length of tubes having one or both ends open, all work and conclusions were experimental.

Two tubes were constructed having good tone and volume qualities. Measurement of these tubes produced a proposed constant ratio between size of opening and the frequency of the tone which could be amplified at a tube length of 9". This constant still needs more testing to be proven true.

MATERIALS

The first step in this experiment was to determine what material was to be used. Several commercially designed chimes were examined and thin walled brass tubing appeared to be the most popular material used. This was probably due to the ease of machineability of this type of material.

The brass stock used in these chimes has an outside diameter of 1.25" and a wall thickness of 0.047". This stock was obtained from the Chase Brass and Copper Company of Madison Heights, Michigan.

EXPERIMENTS

To begin the experiment, an opening was filed in the stock approximately eight inches from one end of the original five foot long tube. This was a round opening 9/16" in diameter. A plug was then constructed of brass sheeting to fit snugly but smoothly inside the tube. This plug was screwed to the end of a dowel rod. This arrangement afforded a moveable end which could vary the length of the tube.

A hollow rubber stopper was placed in the lower end of the tube. When a hose and water reservoir were attached to this stopper, water could be fed in or out of the tube. This water system produced two desirable results. First, it provided an end or plug that would not 'leak' sound waves as a metal plug did and, second, the water level could be raised or lowered a very little at a time thus changing the length of the tube minutely. The ideal arrangement would be to have water at both ends but this is an impossibility.

Musicians tuning forks were used to produce the basic tone so that the exact frequency of each tone could be determined. The tuning forks used had frequencies of 256 vibrations per second (middle C), 392 vps (G), 440 vps (A), and 523 vps (high C).

The experimentation procedure consisted of cutting an opening in the tube, placing the moveable plug in the upper end, and filling the lower end with water. One of the tuning forks would then be rung over the opening. By adjusting the position of the plug and the level of water, the exact length could be found that reinforced the tone the best. This was repeated with each tuning fork and the results recorded. The size and shape of the opening was then altered and the entire procedure repeated. The results of these experiments can be found in the appendix.

MATHEMATICAL COMPUTATIONS

As can be seen in the Appendix I, a length could be found to reinforce the 523 (C) fork with every opening. The lower the frequency, however, the more difficult it was to find a combination of opening and length to produce a tone loud enough to be practical. The [illegible]on for this was not established.

The 440 vps fork resounded the best with an opening of 13/32" x 19/32" and a length of 9". In order to arrive at some constant dimensions, another tube 9" long with a 13/32" wide opening was tested with a 523 vps fork. The only variation made for tuning was the length of the opening. Best resonance was found at a length of 1 3/32". The difference in length of the two openings was 22/32". The difference in frequency was 83 vps. By dividing the difference in frequency by the difference in length, a proposed constant ratio for increasing opening length and frequency can be arrived at. This constant was found to be an increase of 1/32" in length equals an increase of 3.7637 vps.

$$+ 1/32'' = 3.7637 \text{ vps.}$$

It should be noted that this constant would be limited to tubes having the same diameter, length, and a 13/32" wide opening.

FINISHING

After the tube length and size of opening was determined, the tube had to be cut to length, capped at both ends, polished, and lacquered. After cutting the tube to the right length, each end was squared off on the lathe. Caps were cut from light brass sheeting. These caps were soldered onto the ends of the tubes with soft solder which would conform to the round ends before heating. The excess cap material and solder was removed on the belt sander.

To remove scratches and machining marks, the tubes were secured in a three-jaw lathe chuck and wet sanded with a number 150 grit wet metal sanding paper. After the deep scratches had been removed, a number 400 grit emery paper was used, also wet, to bring out a satiny brass finish. Light oil was used as the wetting agent in both operations.

A clear metal lacquer was applied by turning the tubes in the lathe and running a soft cloth dipped in lacquer over the surface. This coat of lacquer will prevent future oxidation and discoloration.

SUMMARY OF CONCLUSIONS

From observation of the results of different shapes of openings and lengths of tubes, several conclusions may safely be made.

From the data shown in appendix I, it is evident that the shape of the opening is a significant key in producing a good resonance. In the first trial a round opening had very little resonance at any frequency. When this opening was elongated the resonance improved. In the second tube the opening was made narrower and longer, while at the same time the total area was kept the same. Resonance was again improved.

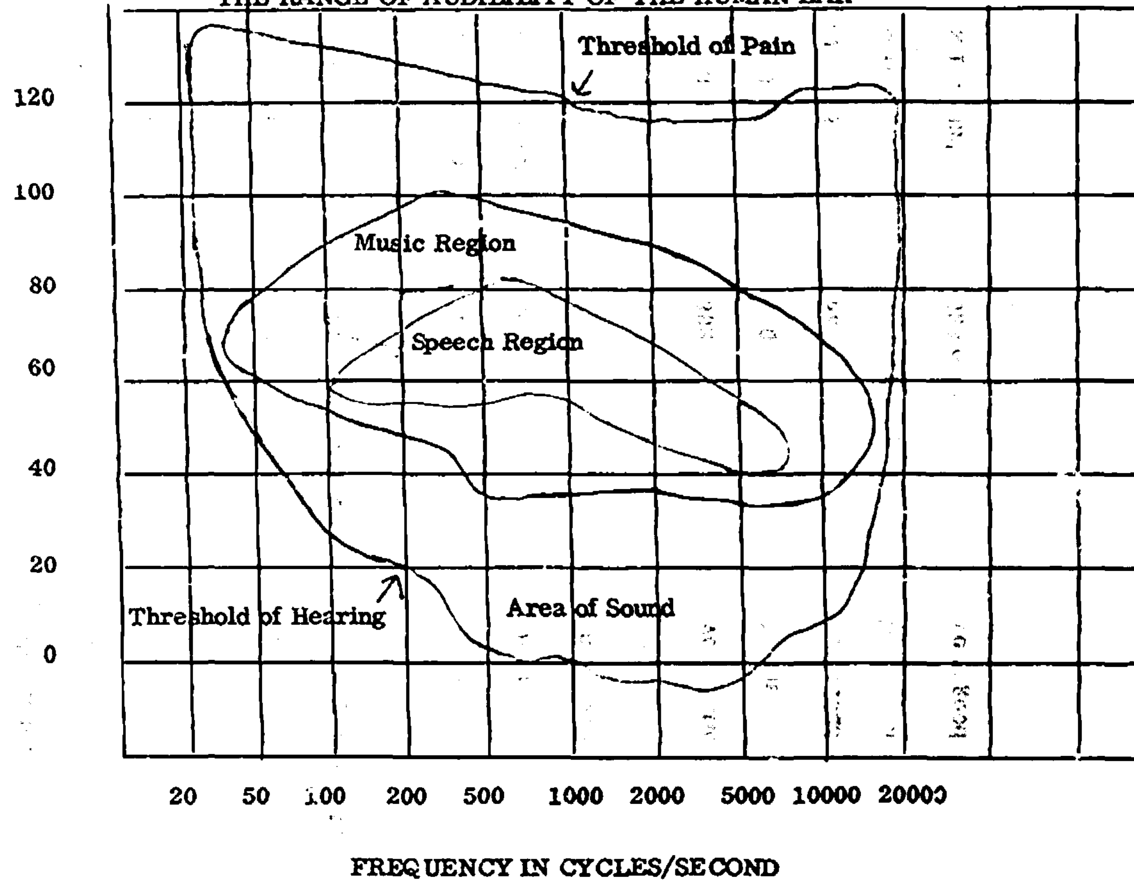
Overall length of the tube was also found to be a large factor in producing a good resonance. In each of the above mentioned trials, the length had to vary every time the size of the opening was changed. In the last two tubes constructed, a standard length of 9" was maintained while only length of opening was changed. A good resonance was achieved in both cases. This would tend to show that there is a definite relationship between the size opening and length of the tube. At a standard opening width of 13/32" and a standard tube length of 9", it was observed that an increase of opening length of 1/32" raised the frequency amplified by 3.7637 vibrations per second. Unfortunately, time allowed construction of too few tubes to arrive at a constant ratio between tube length and overall area of opening. The lack of tuning forks in the 550-700 vps range also hampered the setting up of a constant that could be proven to be true.

APPENDIX I

Size of Opening	Frequency of Fork	Quality of Resonance	Length
9/16" diameter	256	poor	16.5"
9/16" diameter	392	poor	13.0"
9/16" diameter	440	better	11.0"
9/16" diameter	523	best	7.75"
11/16" diameter	very little change at any frequency or length		
5/8" x 1" diameter	256	None	any
5/8" x 1" diameter	392	None	any
5/8" x 1" diameter	440	little	12"
5/8" x 1" diameter	523	moderately loud	9.5"
7/16" x 1 3/16"	256	none	any
7/16" x 1 3/16"	392	very little	
7/16" x 1 3/16"	440	better	
7/16" x 1 3/16	523	quite loud	9.75"
13/32" x 19/32"	440 only	very good	9.0"
13/32" x 1 3/32"	523 only	very good	9.0"

APPENDIX II

THE RANGE OF AUDIBILITY OF THE HUMAN EAR[1]



[1] Charles E. Dull, Modern Physics, P. 304